

Real time x-ray scattering studies of surface patterning and thin film deposition

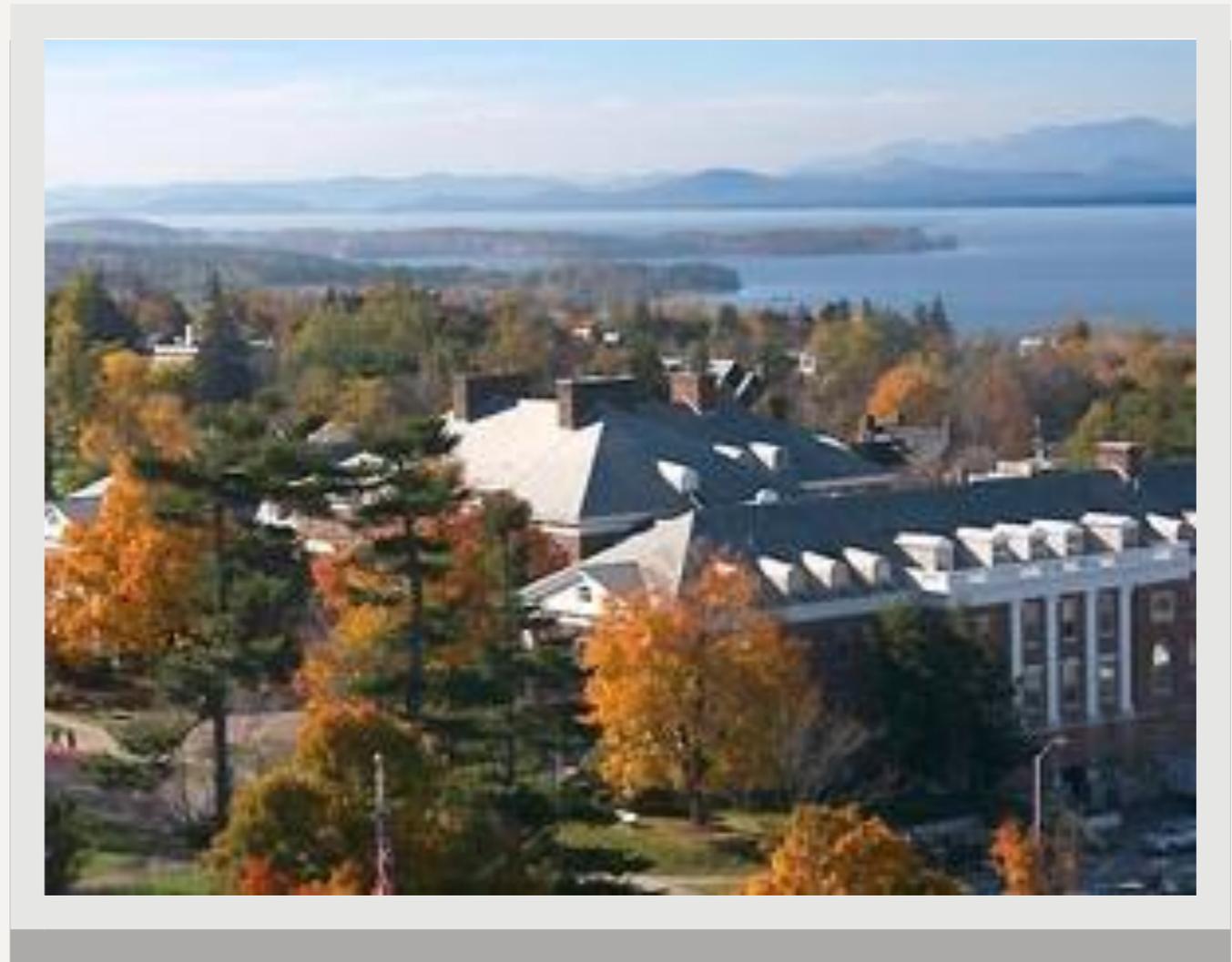
Randall Headrick

Department of Physics

and

Materials Science Program

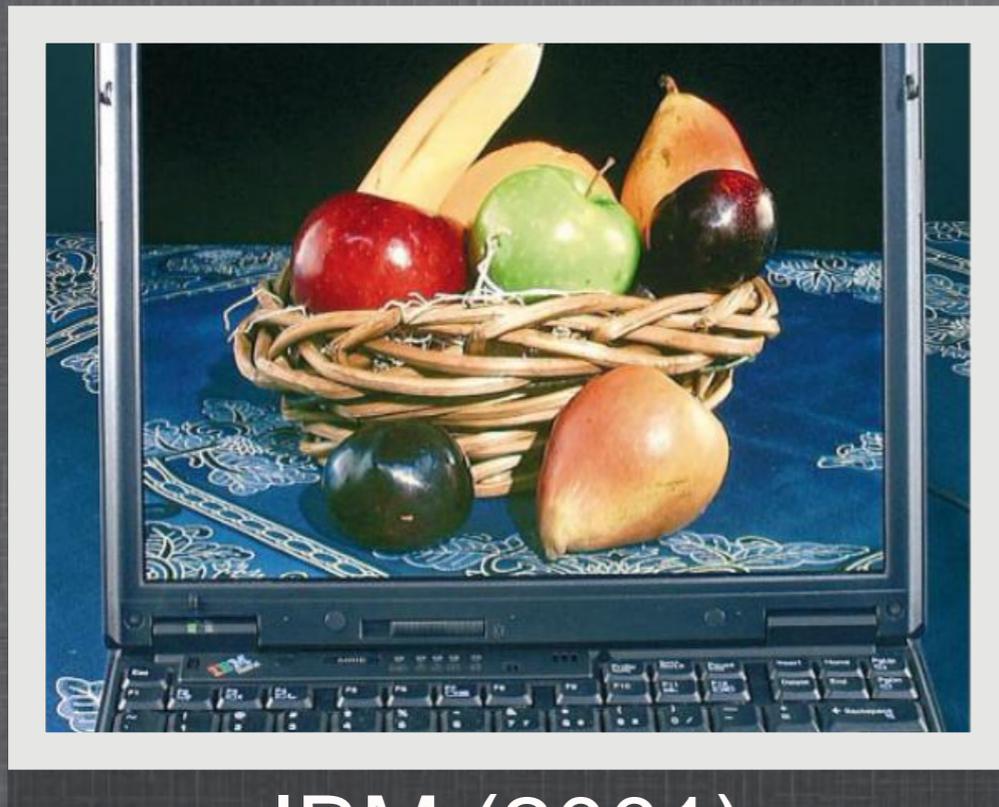
The University of Vermont,
Burlington VT 05405



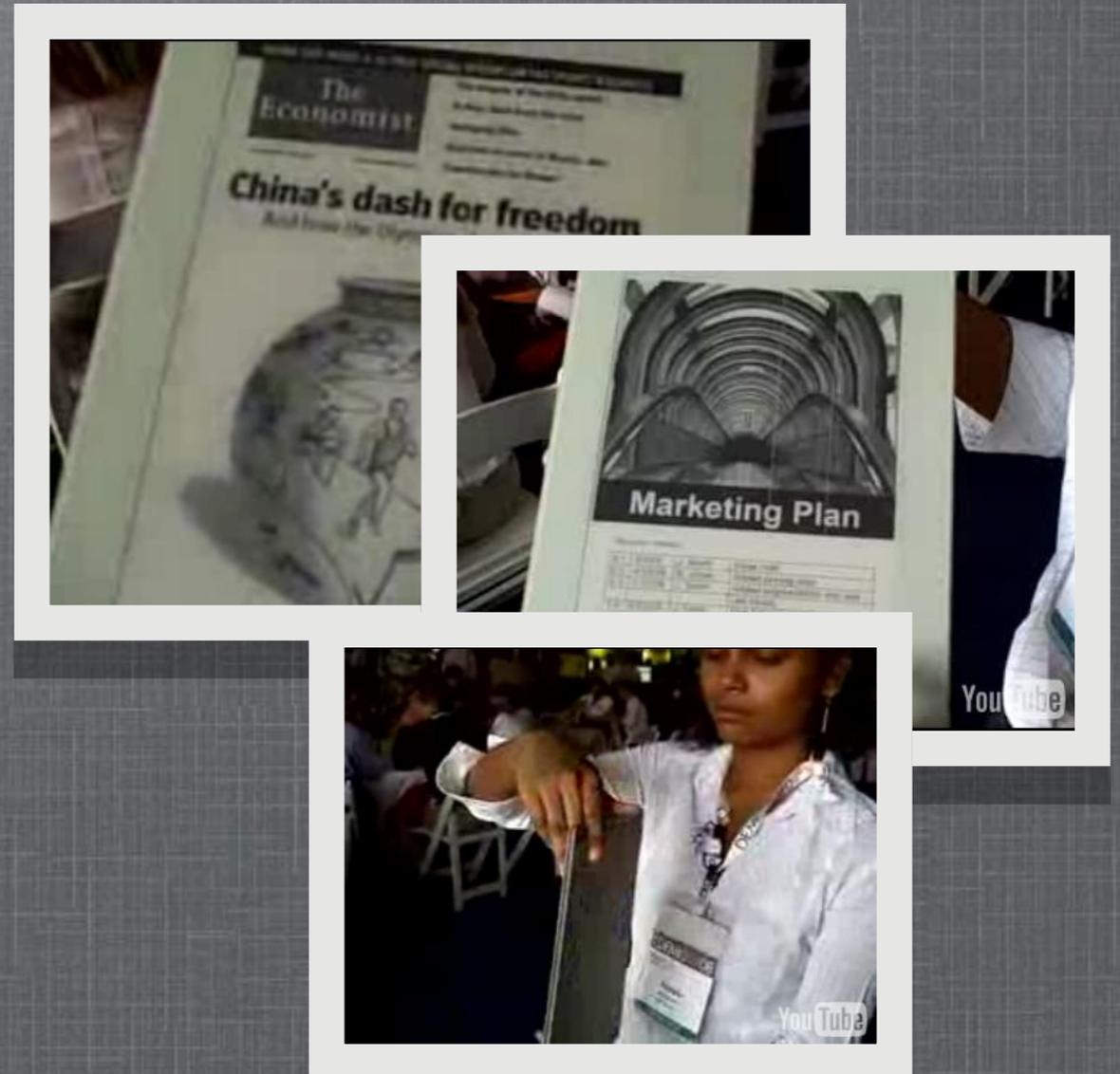
Materials

Overview of research in Headrick's group at UVM

Materials with applications in electronics, for example: **displays**

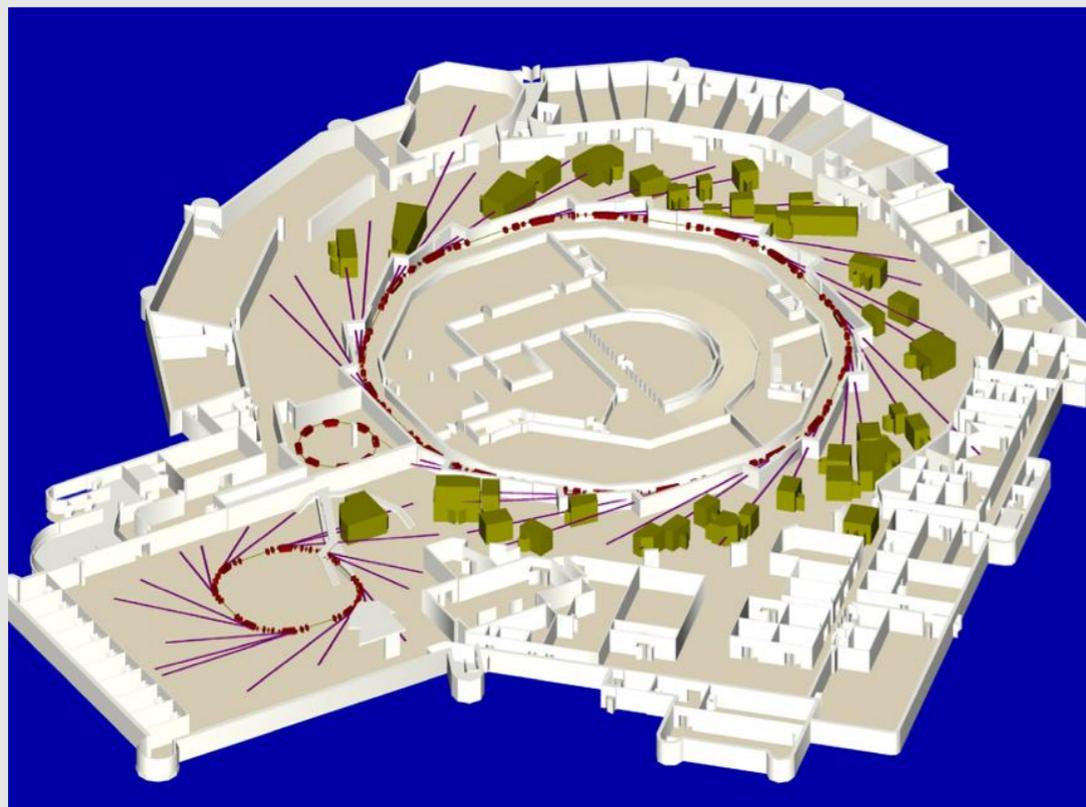


IBM (2001)



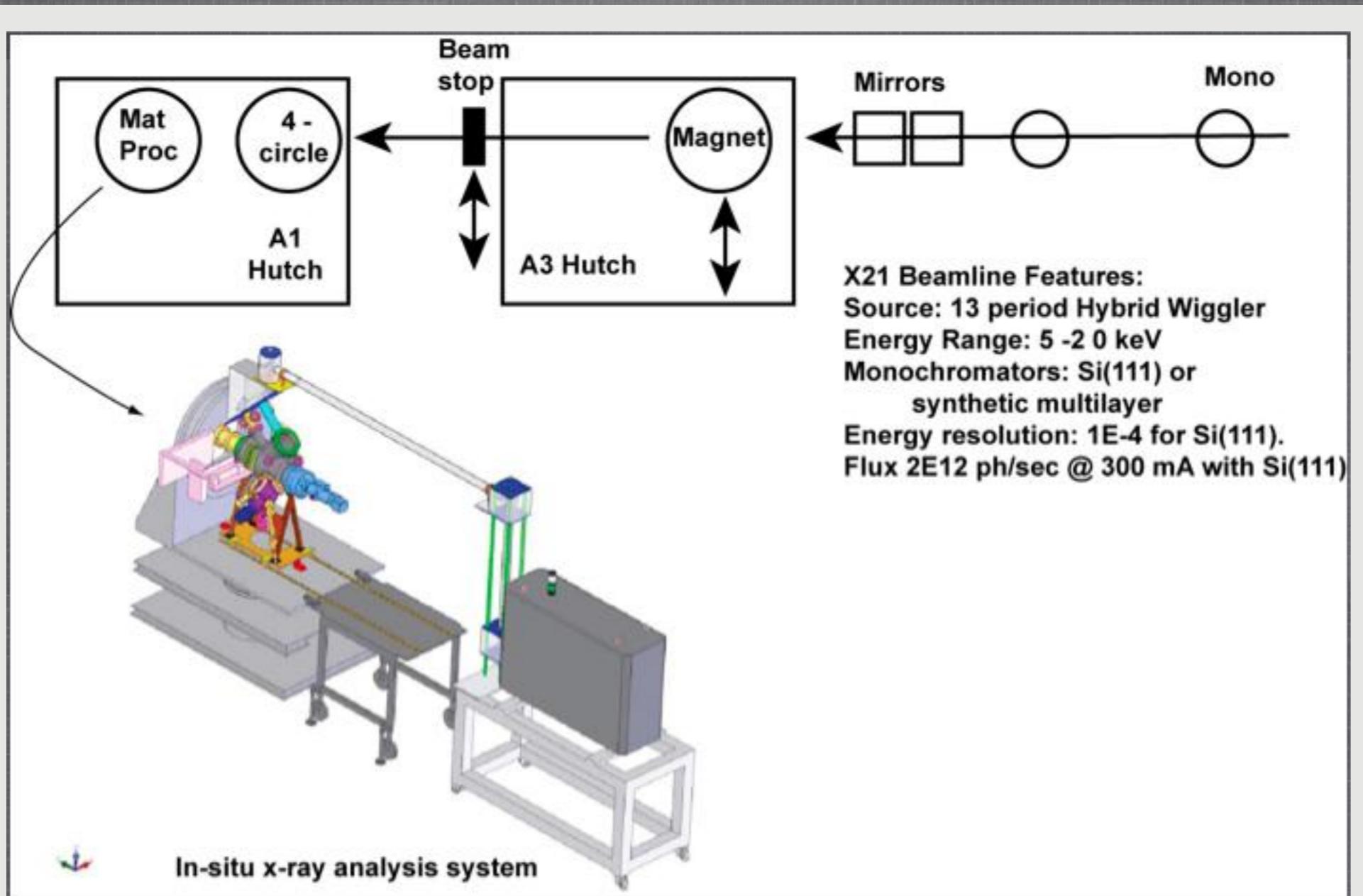
Plastic Logic (2008)

National Synchrotron Light Source

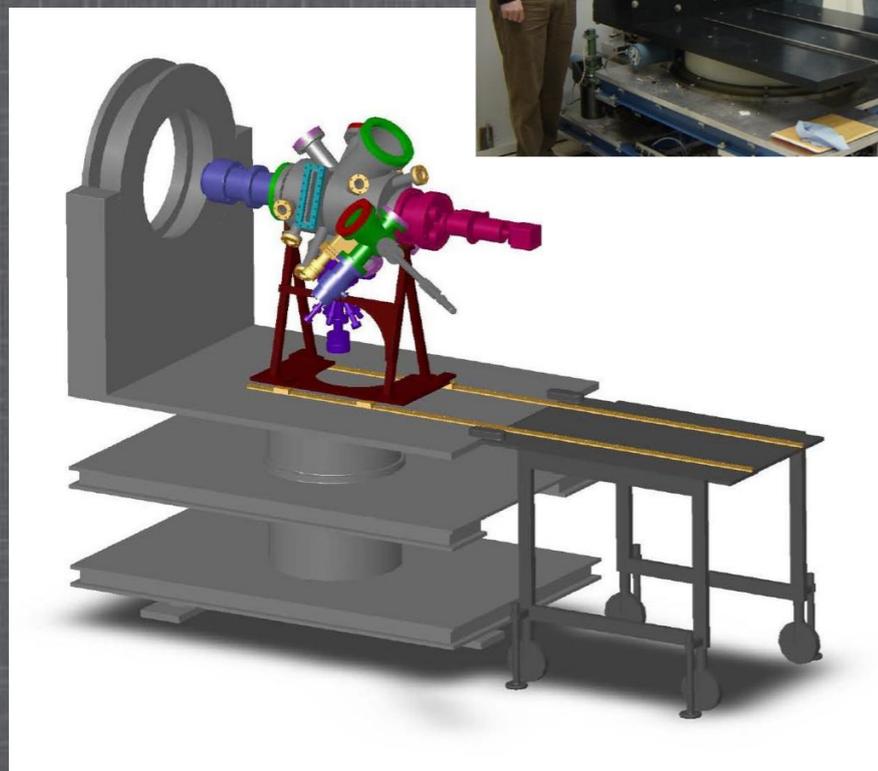
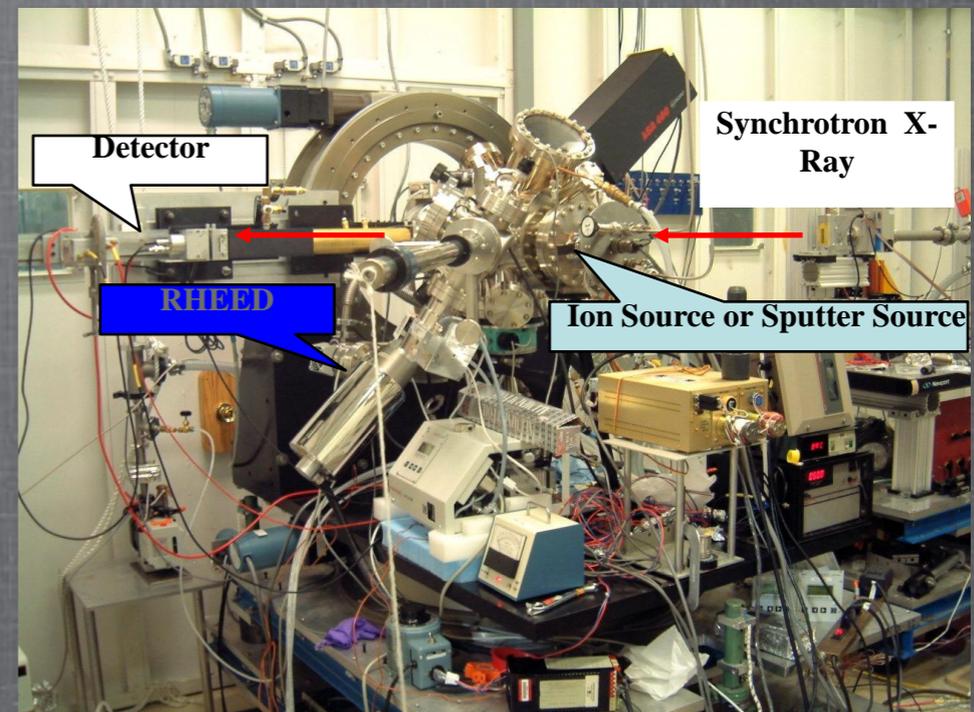
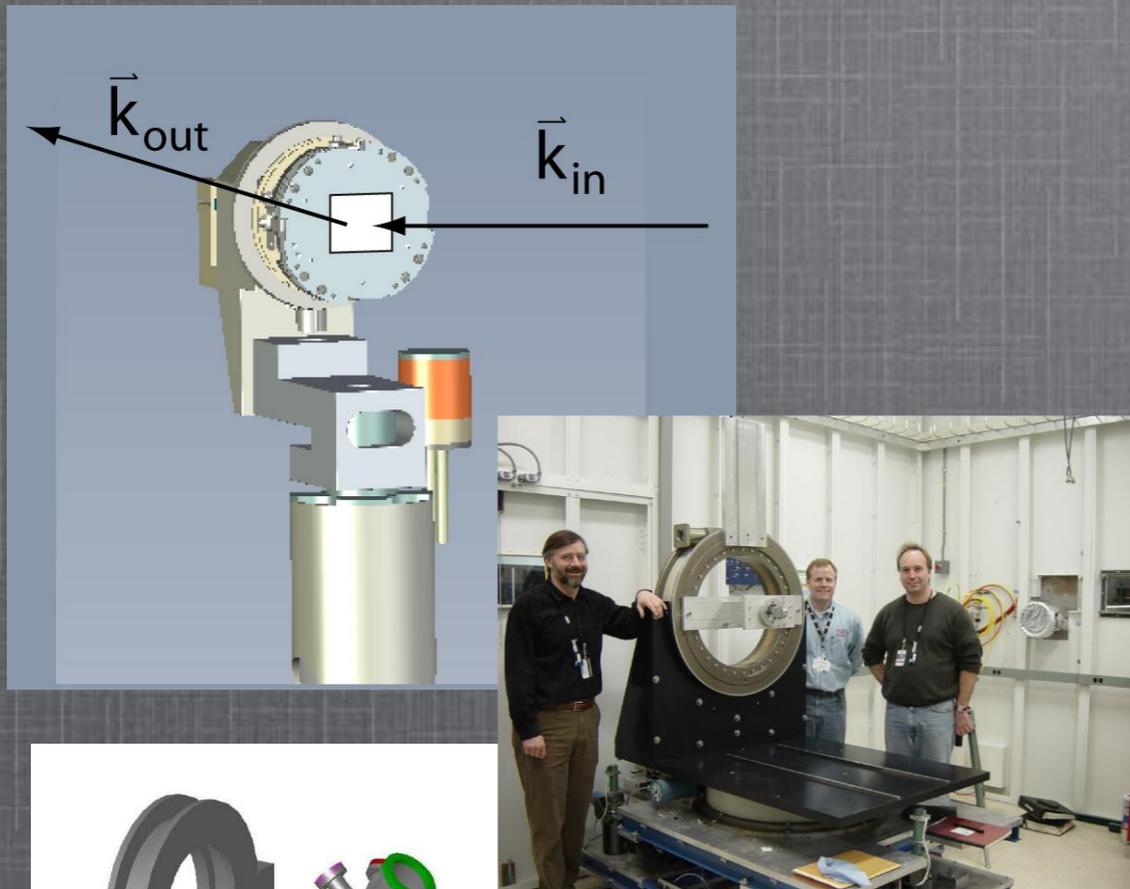


NSLS X21 Beamline

Schematic diagram



In-situ Studies at NSLS X21



Position sensitive linear detector.

3-grid Ion Source (100 - 1000 eV).

Phi Ion Gun (500 - 2000 eV)

Dual-gun Magnetron Sputter
Deposition.

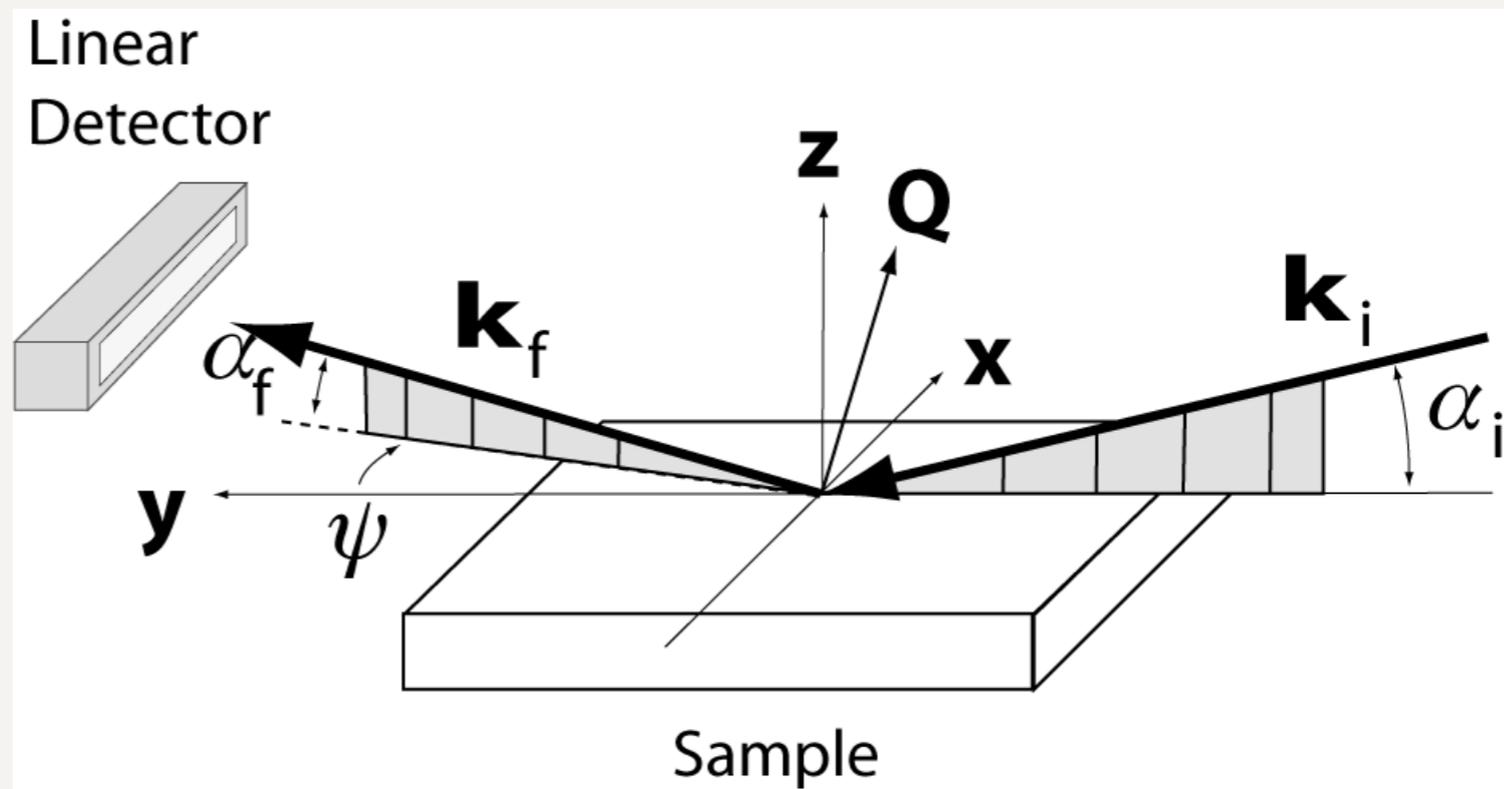
I: SURFACES

SURFACE PATTERNING BY ION BOMBARDMENT

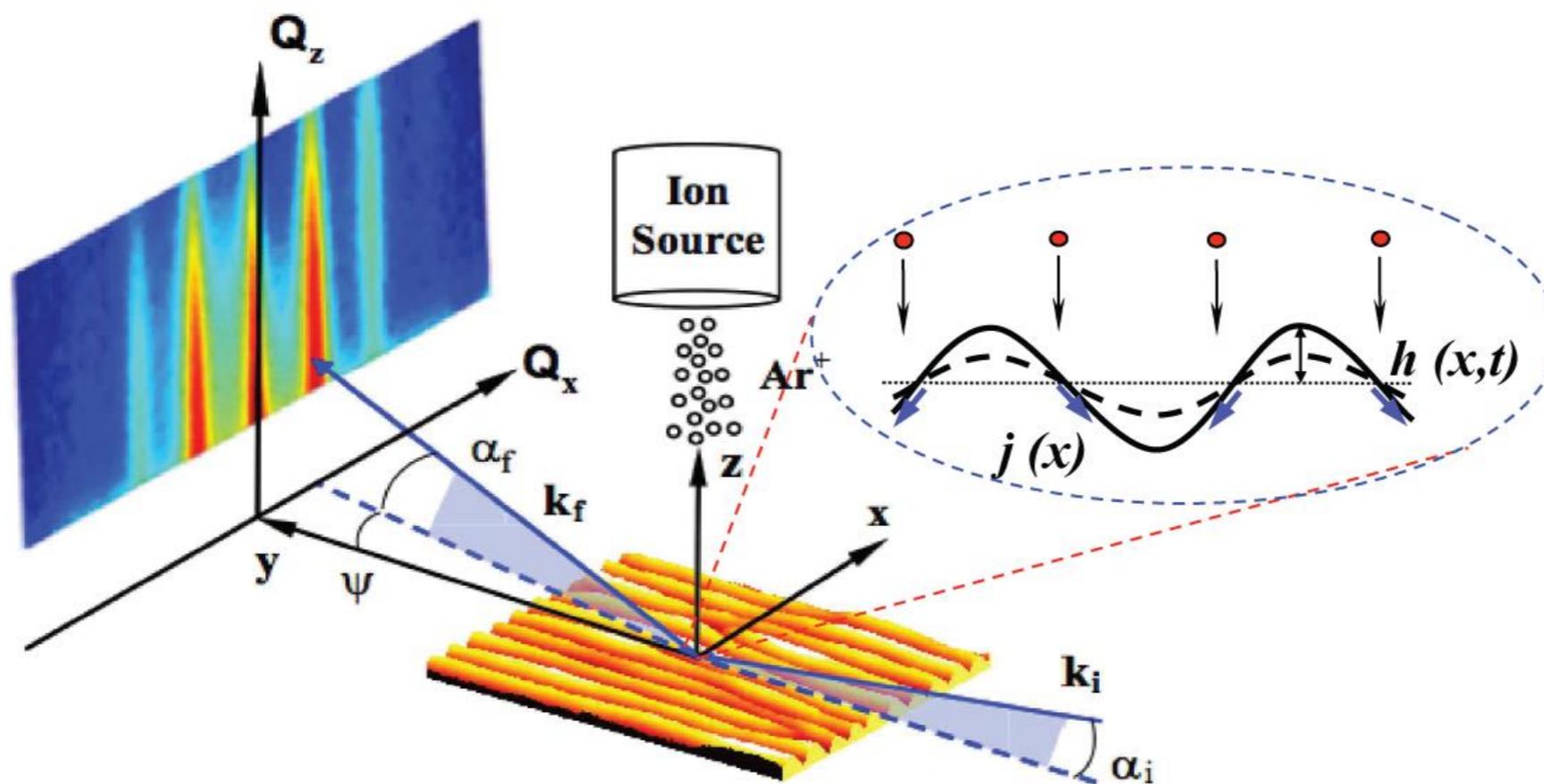
Scattering Geometry

Scan modes:

- Fixed
- Reflectivity
- Scan ϕ_f
- Scan ψ

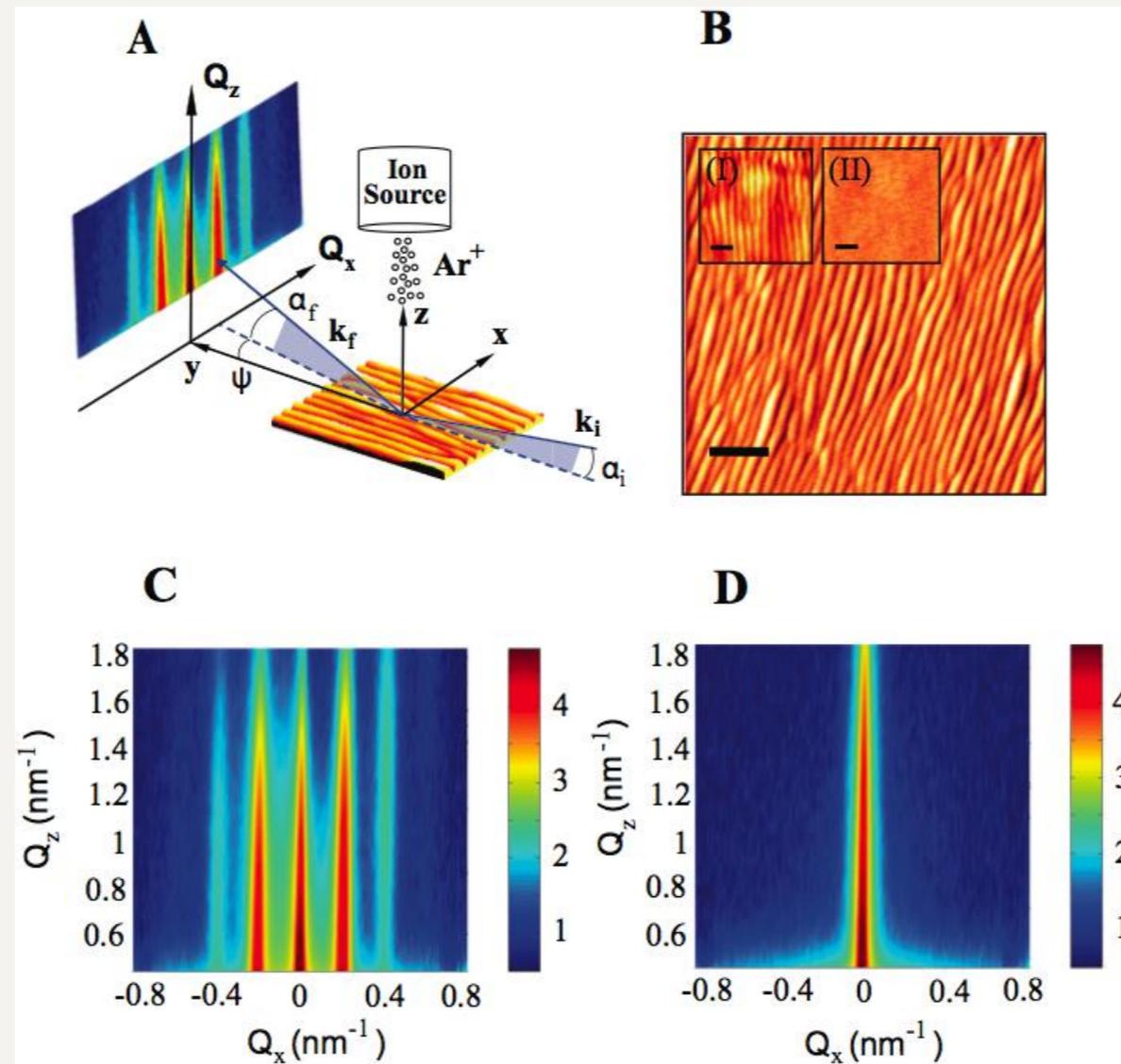


Ar⁺ Ion Smoothing



H. Zhou et al., PRB 75, 155416 (2007) and
PRB 78, 165404 (2008).

Waves created on surfaces with ion beams

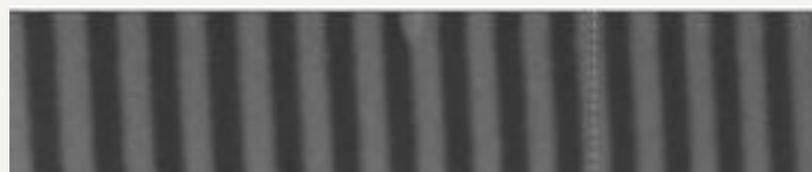


H. Zhou PRB 78, 165404 (2008).

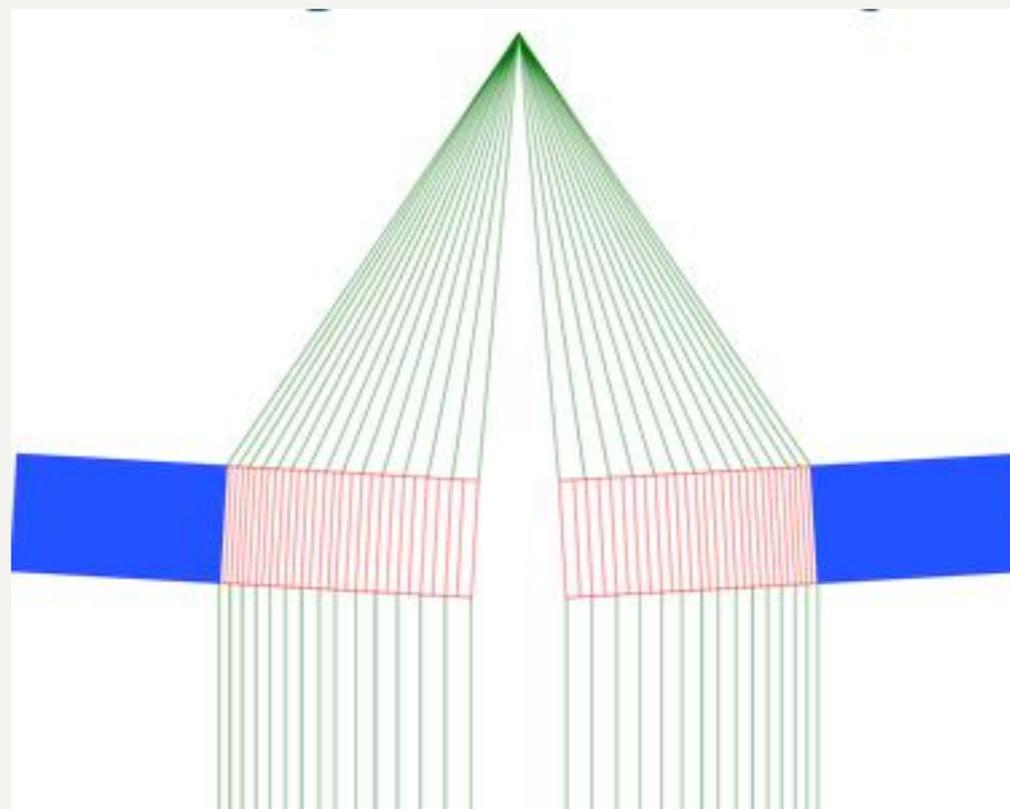
II: INTERFACES

BURIED INTERFACES IN MULTILAYERS

Thin $W\text{Si}_2$ layers for x-ray lenses to the nanometers scale

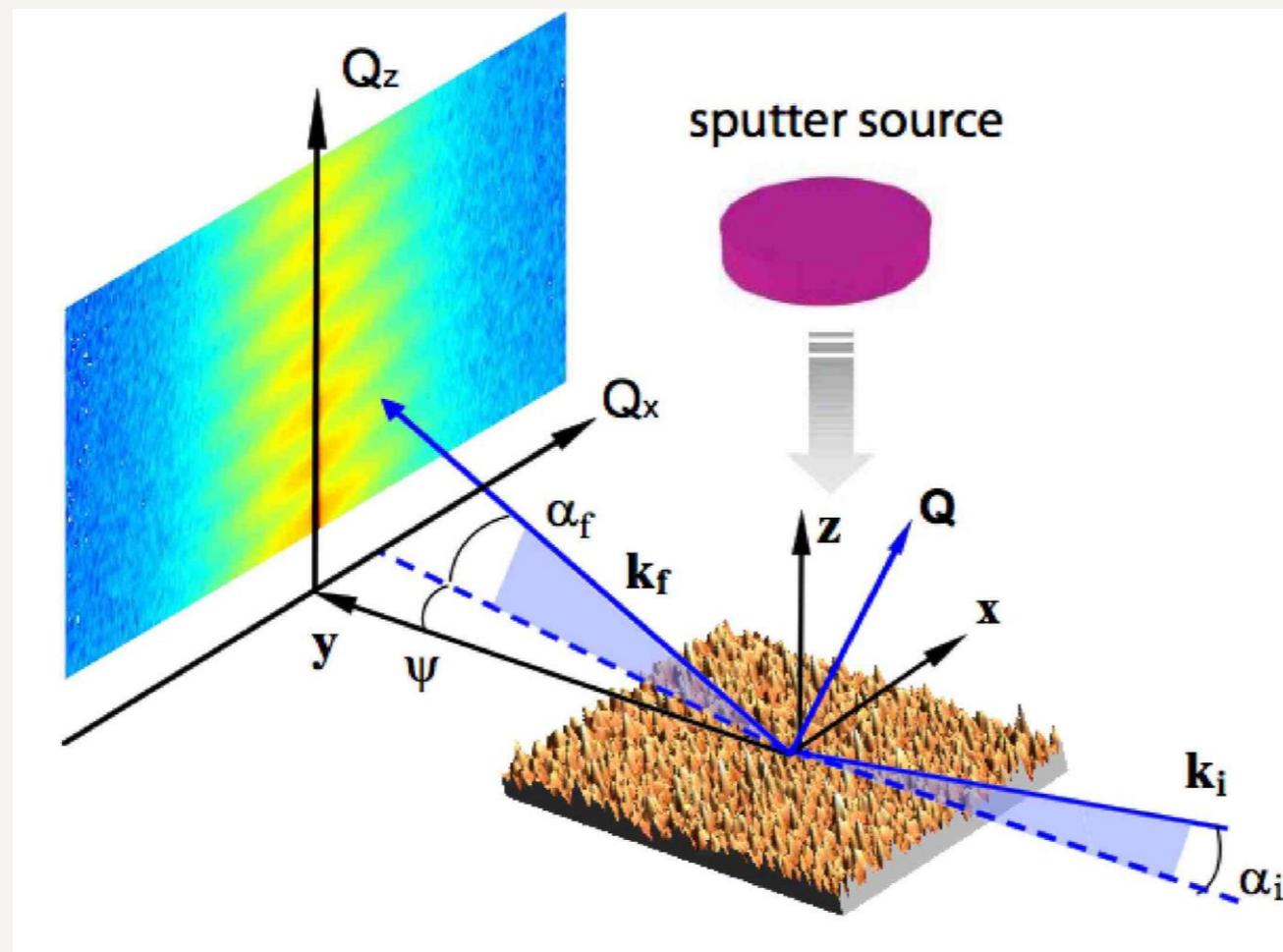


$W\text{Si}_2$ / Si Multilayer



Transmission Laue Lens
Argonne (2005)

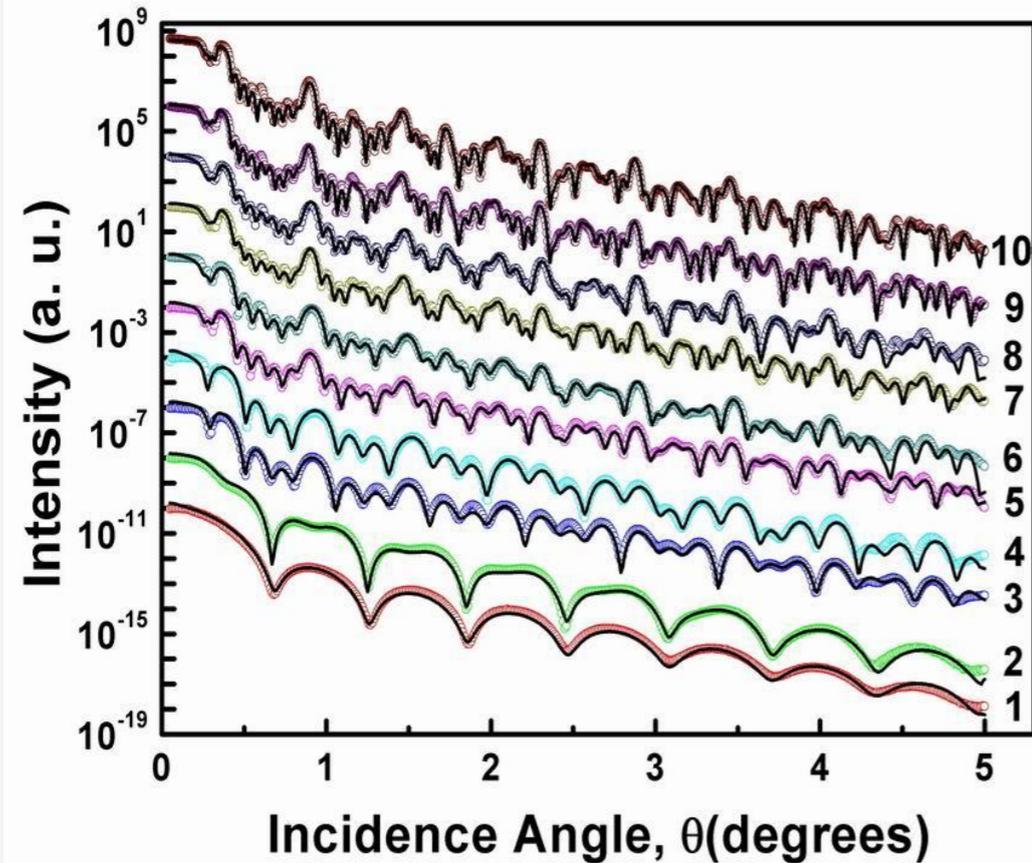
Sputter Deposition: Multilayers



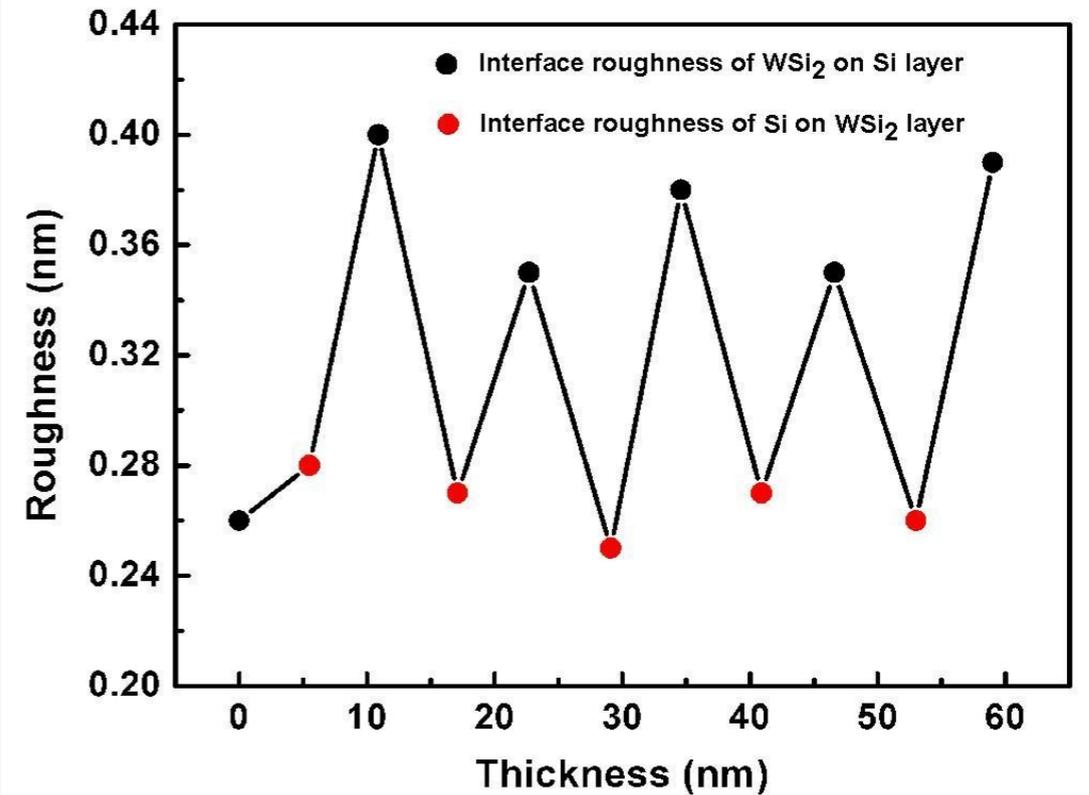
Y. Wang et al., J. Appl Phys. 101, 023503 (2007)

Interface Roughness

WSi₂/Si multilayer



Specular Reflectivity
after each deposited layer.

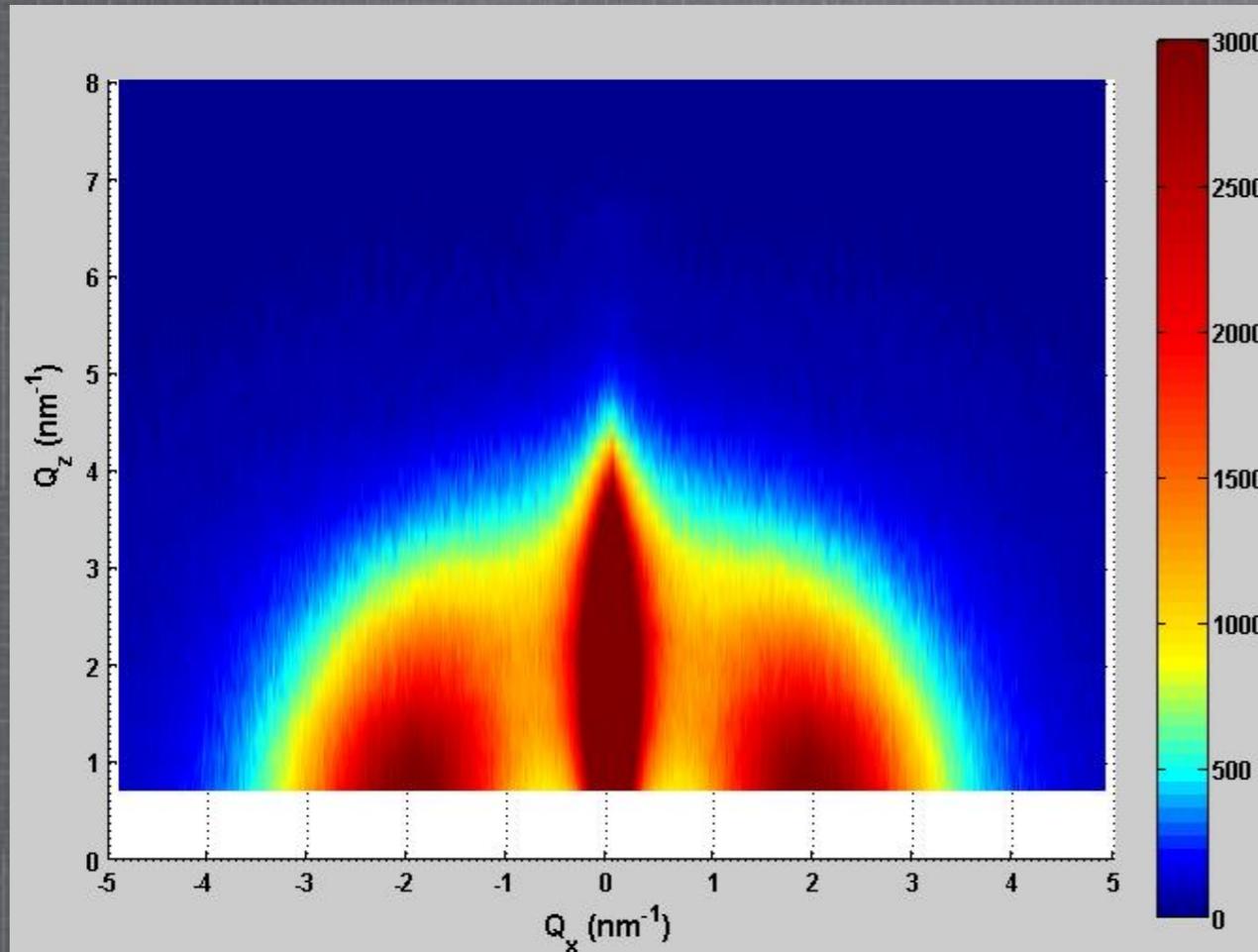


Interface Roughness
from Fitting

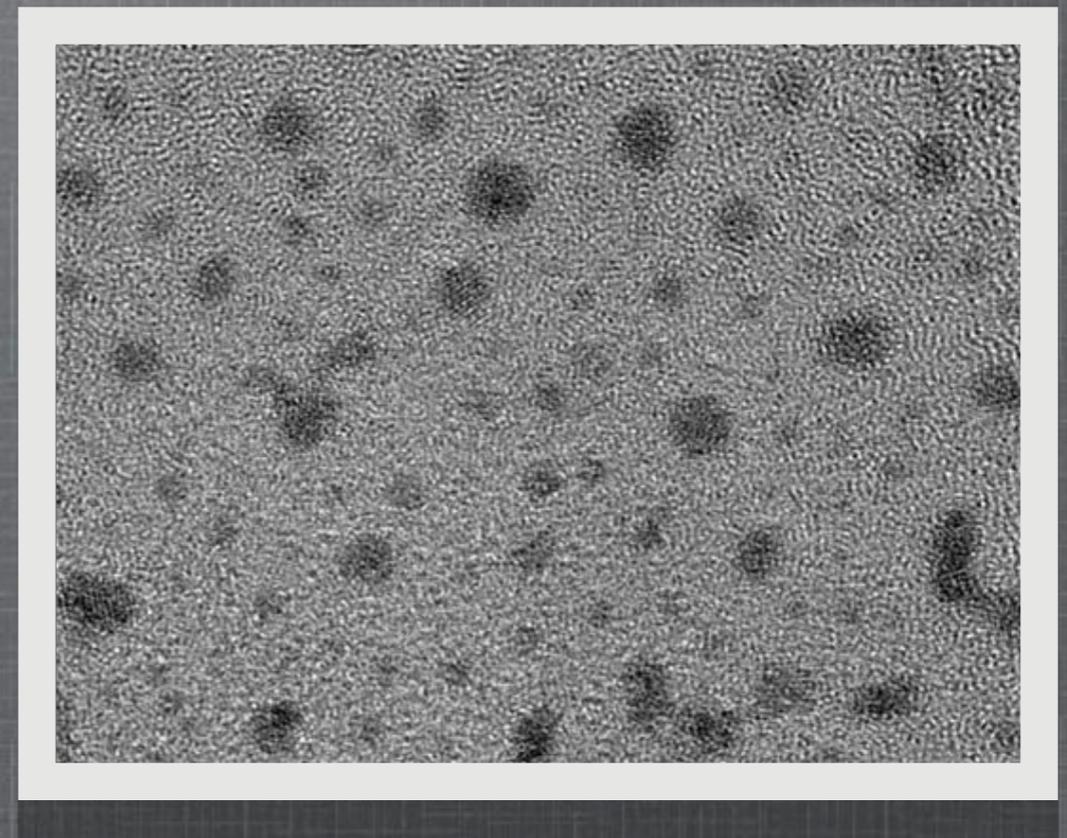
Y. Wang et al., J. Appl Phys. 101, 023503 (2007)

lower limit to thickness ness

1 nm WSi_2 layers are discontinuous



Grazing Incidence X-ray
Scattering at NSLS



Transmission Electron
Microscopy at CFN

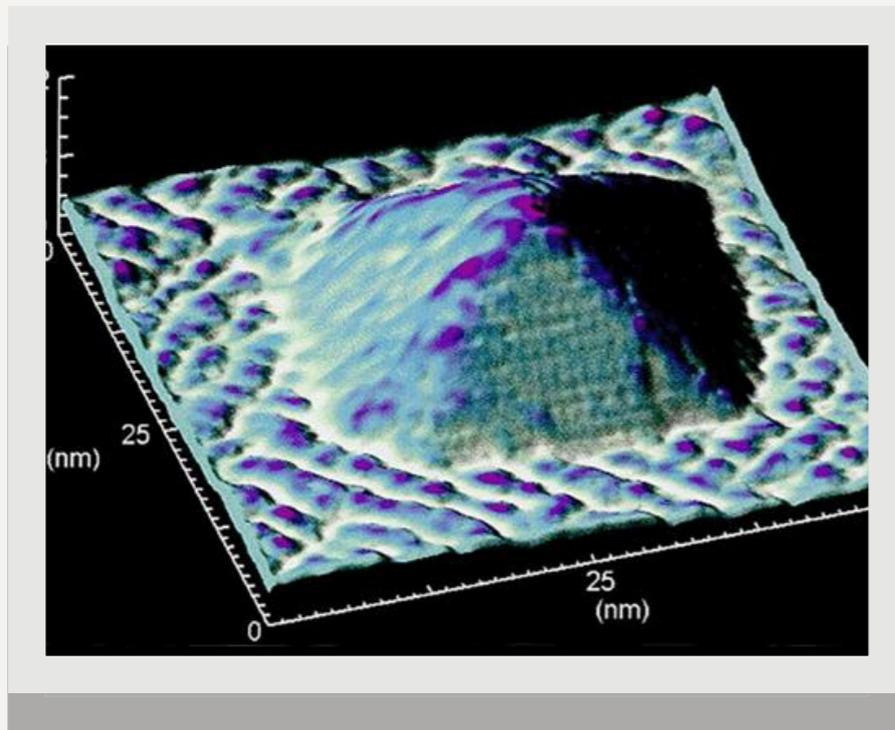
L. Zhou (2008)

III: CRYSTAL GROWTH

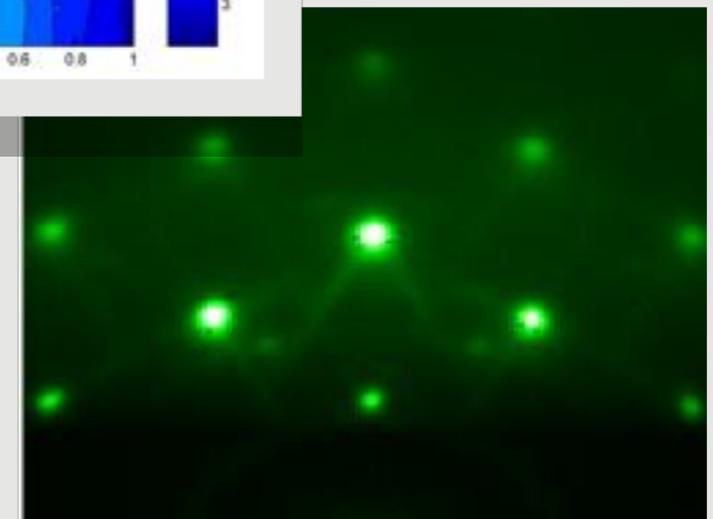
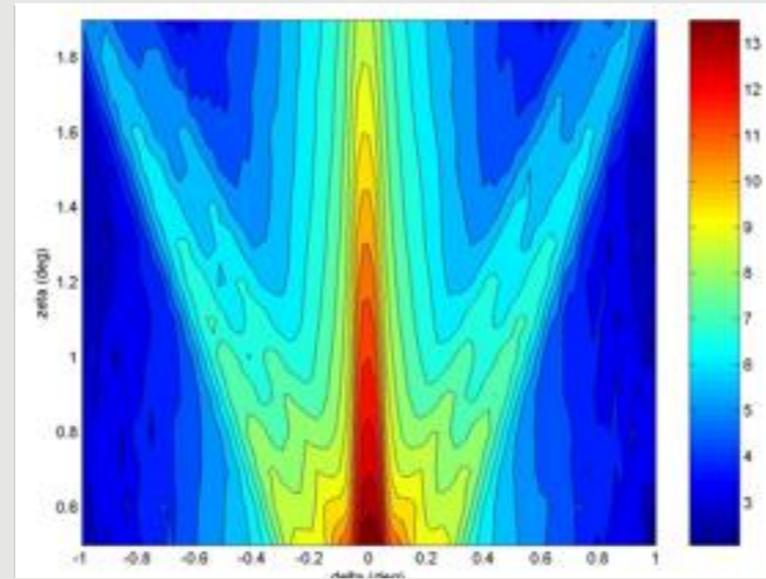
EPITAXIAL GROWTH OF:

GERMANIUM ON SILICON
COPPER ON COPPER SIMULATION
GERMANIUM ON GERMANIUM

Ge Pyramids on Si(001)



Hewlett-Packard (1998)



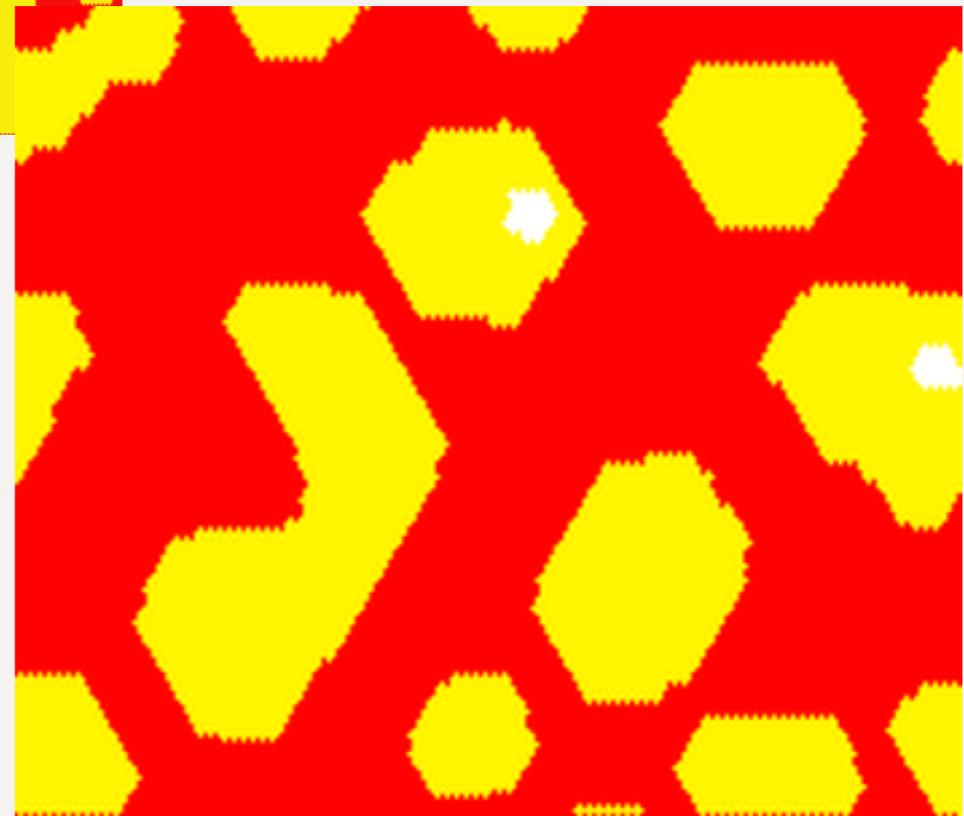
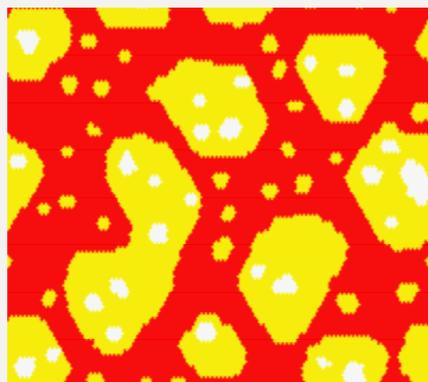
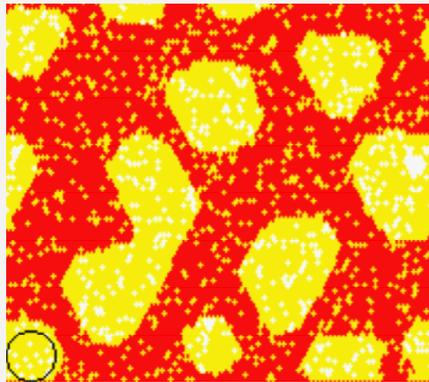
Xu et al. (2007)

Pulsed Deposition of Cu

Instantaneous
pulse

Microsecond
time scale

Millisecond
time scale

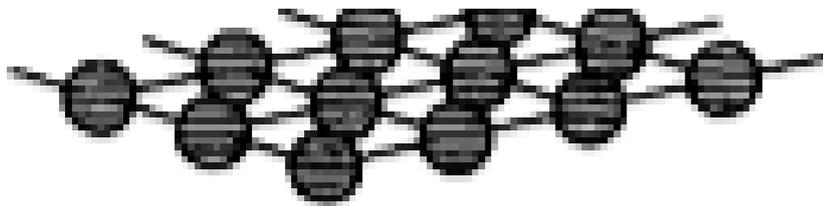


Rushford (2003)

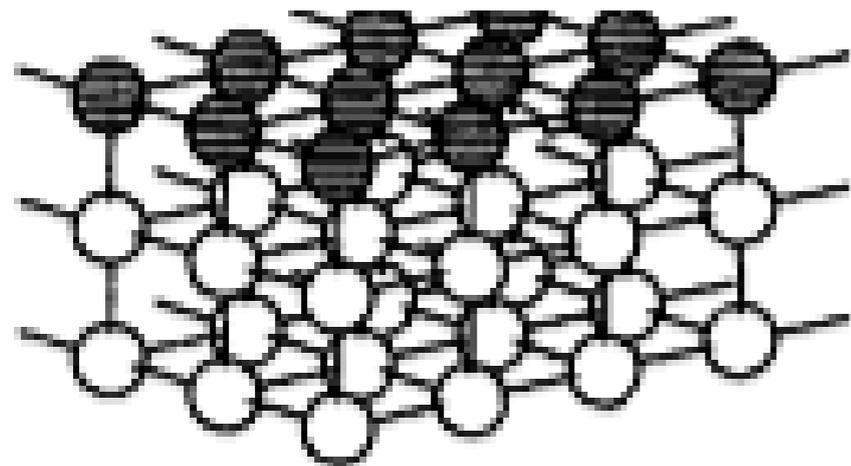
ML and Surface Diffraction

Real Space

Reciprocal Space



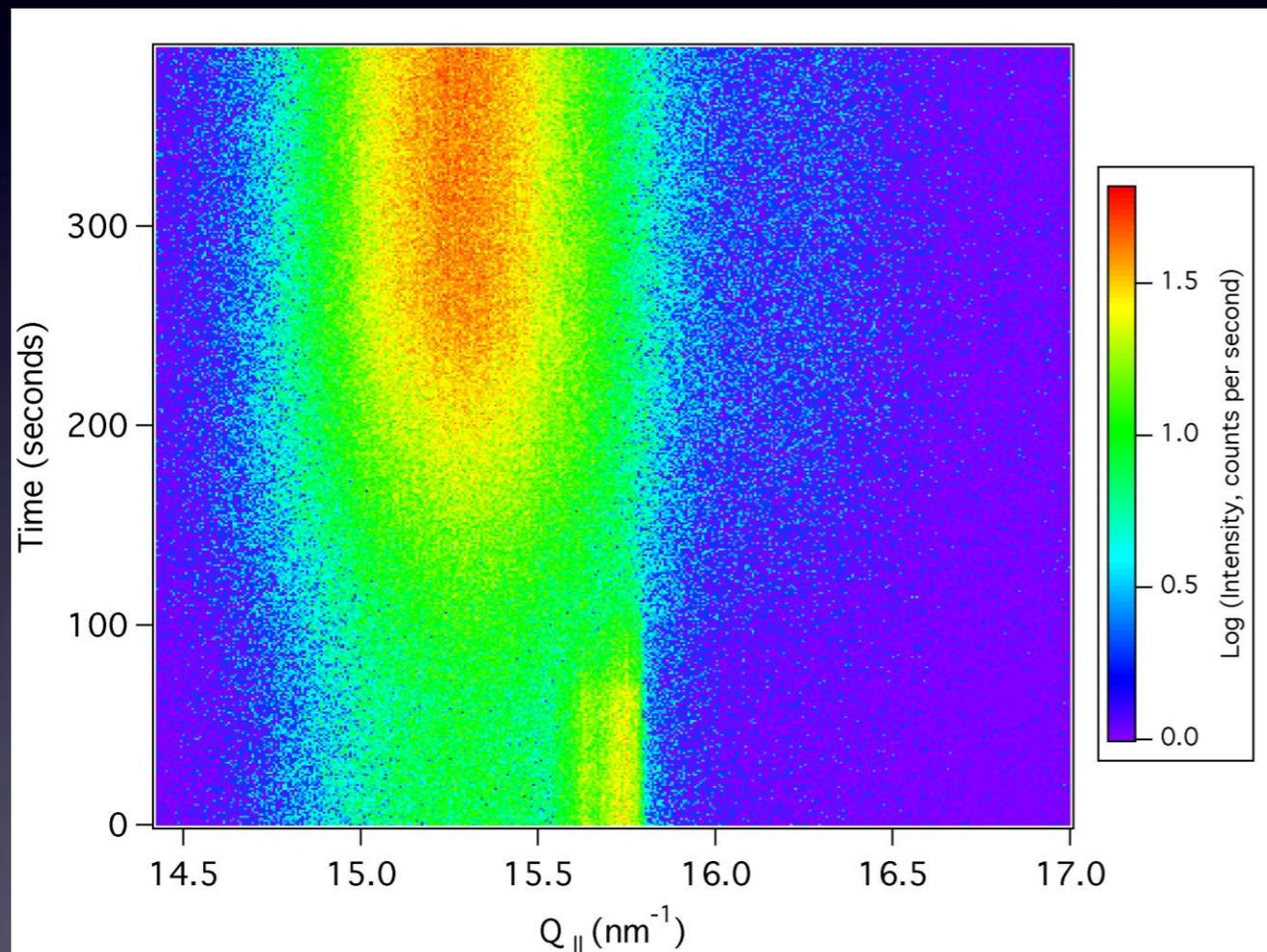
Isolated Monolayer



Surface of Crystal

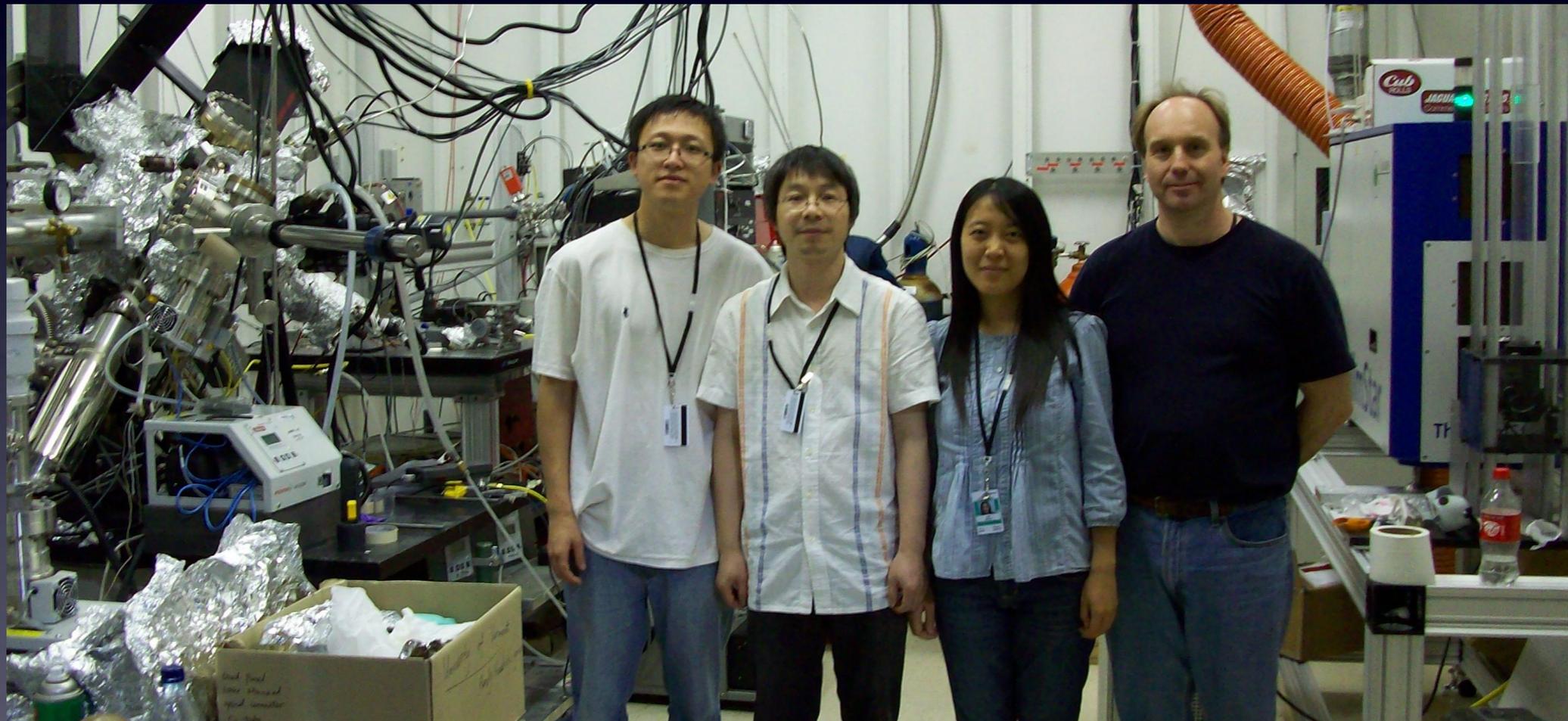


Pulsed Deposition of Ge on Ge(001)



The (1 1 0.05) in-plane surface reflection is initially very close to bulk value of $Q_{||} = 15.74 \text{ nm}^{-1}$. The surface shows a 2.9% change in surface in-plane lattice parameter during the first monolayer of deposition.

My group at NSLS X21, June 2009



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